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Value added by intellectual capital: a study from the brazilian B3´s ISE portfolio – Corporate Sustainability Index

Valor adicionado pelo capital intelectual: um estudo do portfólio ISE da B3 - Índice de Sustentabilidade Corporativa de empresas brasileiras

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Abstract: The study aimed at discussing the Value Creation based on the VAIC™ method and as a research field the companies that are part of the B3 (BM&FBOVESPA) Corporate Sustainability Index (ISE) portfolio. As a first approach, we selected the year 2016 after ten years of ISE history. The VAIC™ components were recovered and computed from the International Financial Reporting Standards ended in December 31, 2015. The hypotheses allowed to affirm the following: (i) there is interdependence among Invested Financial Capital, Intellectual Capital, and Value Creation; (ii) there are dimensions of Value Creation capable of differentiating and clustering the observations; and (iii) the allocative efficiency of companies can vary according to clusters. The main limitation is the size of the population/final sample — 29 corporations. The implications refer to the reinforcement of the theoretical existence of Value Creation based simultaneously on tangible and intangible assets and the possibility to categorize companies to broaden the understanding of the bases for appreciation of the value and pricing of assets traded on the stock exchange platforms.

Keywords: Intellectual capital; Value Added Intellectual Coefficient-VAIC™; Corporate Sustainability Index – ISE.

Resumo: O estudo teve como objetivo discutir a criação de valor com base no método VAIC™ e como campo de pesquisa as empresas que integram o portfólio do Índice de Sustentabilidade Empresarial (ISE) da B3 (BM&FBOVESPA). Como primeira abordagem, selecionamos o ano de 2016 após dez anos de história do ISE. Os componentes do VAIC™ foram recuperados e calculados a partir dos Padrões de Relatórios Financeiros Internacionais, encerrados em 31 de dezembro de 2015. As hipóteses permitiram afirmar que: (i) há interdependência entre Capital Financeiro, Capital Intelectual e Criação de Valor; (ii) existem dimensões de Criação de Valor capazes de diferenciar e agrupar as observações; e (iii) a eficiência alocativa das empresas pode variar de acordo com os clusters. A principal limitação é o tamanho da população / amostra final

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— 29 corporações. As implicações referem-se ao reforço da existência teórica de Criação de Valor baseada simultaneamente em ativos tangíveis e intangíveis e a possibilidade de classificar as empresas para ampliar a compreensão das bases de apreciação do valor e preço dos ativos negociados nas plataformas das bolsas de valores.

Palavras-chave: Capital intelectual; Coeficiente Intelectual de Valor Agregado - VAIC™; Índice de Sustentabilidade Empresarial – ISE.

1 Introduction

In highlighting the relevance of Intangible Assets in corporate performance and economic development, the survey of Hassett & Shapiro (2011) assumed that the value of these resources in the US economy in 2011 would reach between US$ 8.1 trillion and US$ 9.2 trillion with total assets (Economic Capacity plus Intellectual Capital) reaching US$ 14.5 trillion, implying that practically two out of three monetary units are due to intangibles.

When contrasting these estimates with the American GDP of that same year at US$ 15.52 trillion (IBRD, 2016), and regarding that intangible to tangible investment ratio change from 0.66 to 1.50 in the last 40 years (Monga, 2016), the structural importance of Intellectual Capital (IC) management for the stakeholders increases both as a source of wealth and as an artifact for risk management.

Hassett & Shapiro (2011) investigated the measurement and added value of IC in 24 industries including energy, banking, telecommunications, semiconductors, equipment and pharmaceutical. In their findings, the IC ratio in comparison to the Market Value of these corporations reached an average of 44.16%, meaning that the companies listed on the stock market in the US could be traded for double the amount accounted as equity.

Pulic (2000) already emphasized the need to demonstrate how companies' financial and intellectual potential can be harnessed (Sardana, 2015) so as to focus on the efficiency of business activities and to identify whether such operations are creating or destroying value. This approach is based on Value Added Intellectual Coefficient (VAIC™) method, which seeks to structure a reasoning for measuring the efficiency of Value Creation in companies (Pulic, 2000).

Thus, the higher the VAIC™, the greater would be the firm's efficiency in Value Creation. The model is considered a tool to measure Value Creation efficiency that derives from the Invested Financial Capital (FC), expressed by the stockholder’s equity, and the Intellectual Capital (IC), expressed by the Human Capital (HC) and Structural Capital (SC). Despite the seminal theoretical conceptions of Sveiby (1997) and Stewart (1998), Pulic (2000) opted not to include in the formulation of the VAIC™ model any informational content capable of characterizing intangible assets of the external structure or the “Relational Capital”.

According to Pulic (2000), it is necessary to measure and document Value Creation since it is an effective tool for managing the performance of companies, contributing to the optimization of financial economic potential and to maximizing Market Value. For Zia ul haq et al. (2014), from the use of data obtained through financial statements, the VAIC™ model can provide reliable information on how and when the Intellectual Capital and Invested Financial Capital add Value.

Based on these reflections we conjectured our research question that consists in how and how intensely the dimensions that underpin the VAIC™ model interact in the

Value Creation of the companies listed in the B3 (BM&FBOVESPA) Corporate Sustainability Index (ISE).

Although the study of Value Creation from Intellectual Capital components is embryonic in Brazil, and despite some skepticism regarding the VAIC™ Model (Ghosh & Maji, 2015; Ståhle et al., 2011), we assumed for this research that applying the VAIC™ would allow searching for traces of how Intellectual Capital takes on different levels of importance in each organization. The assumption for the sample definition is that the companies engaged in reaching the sustainability triple bottom line would tend to support their choices and action plans in flows and stocks of knowledge and interactions typical of intangible asset management. In this sense, the ISE portrays a subset of corporations in the Brazilian stock market with the main discretion for participating being compliance with social, environmental, and economic simultaneous guidelines.

In Brazil, the ISE portfolio and Value Creation as a whole have been the subject of studies from different perspectives, for example, corporate responsibility (Teixeira, 2016), intangibility (Medrado et al, 2016), and the use of Integrated Reporting (Alves et al., 2016) without a clear and objective definition as to the recognition and appreciation of intangibles for the purpose of pricing the shares of companies traded on stock exchanges. We conducted the research based on an Intellectual Capital literature review and its liaisons with the economic-financial performance of companies using the seminal article about the VAIC™ methodology (Pulic, 2000) as well as other articles that made use of this method. The description of the composition of the 2016 ISE portfolio and the aspects of its design and methodology was essential for the foundations and discussions of this paper.

The terminology originally proposed by Pulic (2000) for the VAIC™ methodology was adapted to allow better alignment with recurrent terms in the mainstream contemporary research on Intellectual Capital. In this way, we expanded the scope of the original research, including as a contribution the discussion of Market-To-Book Value (MTBV) as a metric that evidences Value Creation in order to explore the existence of any latent relationship between VAIC™ and MTBV.

Thus, some evidence was found in the following regards: (i) interdependence among the drivers of Value Creation based on Intellectual Capital; (ii) misalignment between calculating efficiency through the VAIC™ and the attribution of value through the MTBV index for the ISE portfolio as a whole; (iii) existence of different Value Creation standards for different categories of companies; (iv) predictive capacity to categorize companies based on the VAIC™ components; and (v) relative and comparative importance of Value Creation drivers when considering the categorization based on the cluster analysis.

2 Intellectual capital and economic-financial efficiency

The meaning of Intellectual Capital covers the intangible aspects of a firm and can be understood as a "[...] set of knowledge found in organizations that add value to non-monetary products by the transformation and/or maximization of knowledge-intensive activities [...]" (Ferenhof et al., 2014, p.17). The process of Value Creation of modern corporations, as well as of economic systems, is largely promoted by the incorporeal, the immaterial, and the intangible. For Zambon (2003), in the current context of the knowledge-driven economy where innovation, services, and intangibles play a relevant role in the evolution of companies, regions, and countries, the disclosure and

measuring of Intellectual Capital becomes a crucial instrumental condition for this new type of development.

According to Stewart (1998) in his seminal propositions, data and information, when processed over time, generate knowledge, which encompasses expertise and insights offered by individuals. This act of knowing offered by the individual, when segregated and aligned with the organizational objectives, generates the corporate knowledge that is then reflected in the products and services that aim to meet the specific needs of clients.

In discussing intangibles, Sveiby (1997) places them as a set of internal and external competencies and structures that have knowledge as the guiding thread, which gives them authenticity. This view of the organization fundamentally composed of intangible assets is the transition from an old to a new model, that is, to the new economy.

For Souza et al. (2005), physical assets such as goods, inventories, factories, machines, and equipment have become commodities over time and do not currently bring a competitive advantage for organizations. Intellectual Capital, therefore, becomes an essential prerequisite for a knowledge-based economy (Pulic, 2000). In the academic practice, Intellectual Capital has been segmented into dimensions such as Human Capital, Structural Capital, and Relational Capital (Bontis, 1998; Booker et al., 2008; Reina et al., 2010).

In emphasizing the importance of measuring Intellectual Capital, Pulic (2000) reinforces the need to demonstrate how the financial and intellectual potential of companies can be harnessed. Another aspect reinforced by the author refers to the need to monitor efficiency of business activities so as to know if they are creating or destroying value. For Pulic (2000), the Value Creation processes must be measured and documented because managing the Value Creation of companies can optimize their financial economic potential and maximize their Market Value.

Due to the interest and quantity of issues still to be unveiled, the studies on Intellectual Capital include retrospective and cataloging of methodologies (Pew Tan, Plowman & Hancock, 2008), as well as studies with propositions to advance in the state-of-the-art (Zambon & Monciardini, 2015).

The global economic perspective on the importance of intellectual Capital and its effects for Value Creation and wealth generation purposes can be identified from the studies by Nadeem et al (2017) covering 6,045 observations from companies listed in the stock markets from Brazil, Russia, India, China, and South Africa (BRICS) from 2005 to 2014, identifying that the efficiency of Intellectual Capital is significantly associated with return on assets and return on equity.

Furthermore, Kanchana & Mohan (2017) found extensive literature to support propositions that knowledge as an intangible asset represents 75% of the wealth of contemporary organizations, while the discussion of these effects in developing countries is still undersized.

3 The VAIC™ measurement model

The Value Added Intellectual Coefficient (VAIC™) approach (Pulic, 2000) implements five steps. The first one refers to calculating the Value Added (VA), which according to Pulic (2000) represents the outflows — revenues from products or services—while subtracting the inputs — or operating expenses (including disbursements with employees who are not, according to Pulic, considered as costs).

The second step is computing the Invested Financial Capital Efficiency index (FCE), which indicates how much added value was created by one monetary unit invested in Financial Capital.

The third step consists in calculating the Human Capital Efficiency (HCE) wherein is demonstrated how much added value was created per monetary unit disbursed with employees.

The fourth step indicates the Structural Capital Efficiency (SCE) in the Value Creation as the ratio between Structural Capital (SC) and Value Added (VA) with Structural Capital being computed as the subtraction between value added and human capital.

The last step comprises calculating the VAIC™, which can be obtained by adding the coefficients of Invested Financial Capital and Intellectual Capital (Human Capital + Structural Capital). It identifies the components of both Financial and Intellectual Value Creation.

Thus, the higher the VAIC™, the better the efficiency in creating value. The model is presented as a tool to measure Intellectual Capital efficiency. For Zia ul haq et al. (2014), by using data obtained through financial statements, the model can provide reliable information on how and when Intellectual Capital and Financial Capital add value, and also for Nazari & Herremans (2007), the VAIC™ model is presented as an accounting tool that proposes to measure Invested Financial Capital and Intellectual Capital according to Figure 1.

But Pulic's original VAIC™ framework operates on a different basis since Pulic adopted the sense of own invested capital and used as a Financial Capital proxy the companies' accounting equity—the Book Value.

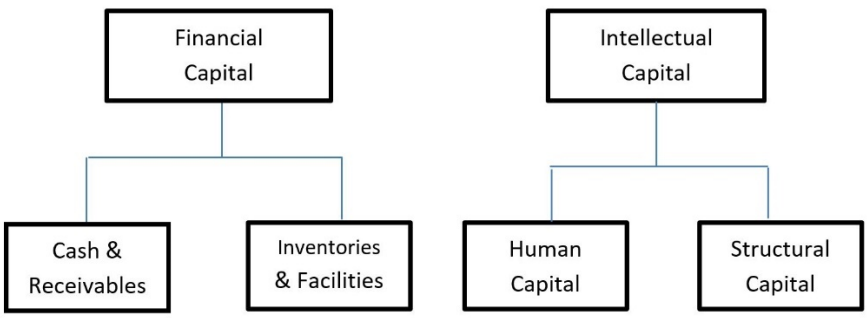

Figure 1. VAIC™ framework. Source: The authors, based on Nazari & Herremans (2007).

Such propositions are shared by Svanadze & Kowalewska (2015) as a simple and effective method because the data used for the necessary calculations are derived directly from the financial statements, allowing the comparison among companies. In addition, the sources of the data used, including the financial statements, are reliable and verifiable. It is a transparent, simple method that is easy to use.

Other researchers have also used the VAIC™ method in their investigations, such as Iazzolino et al. (2014). These authors focused on discussing a different perspective of added value provided by the VAIC™ conception. For them, this model shows the measure of value added from the point of view of the stakeholders when considering the distribution of value added (employees, government, shareholders, society) and not only of shareholders, as in the EVA™ (Economic Value Added) method.

The research of Zia ul haq et al. (2014) aimed at applying the VAIC™ method to examine the efficiency of private and government commercial banks in Pakistan. As a result, a strong correlation was found between IC and bank performance. On the other hand, it was also observed that government banks do not optimally use IC.

Ståhle et al. (2011) analyzed the validity of the VAIC™ and tested Pulic's hypothesis regarding the possibility of estimating a firm's market value based on that methodology arriving at findings that endorse criticism regarding the feasibility of VAIC™ to interact with the essence of Intellectual Capital (IC). One of the main considerations refers to the overlapping of mathematics since the variables adopted as efficiency metrics in the VAIC™ method are computed by complementarity. Thus, the Structural Capital indicator wouldn't correspond to the theoretical main current on IC research, representing a traditional accounting reference with restrictions related to the misuse of the flows against the inventories' value.

Based on research conducted with 62 Indian knowledge-intensive firms, Ghosh & Maji (2015) identified that although the coefficient of Value Added Intellectual Capital as a whole can be considered as a measure associated with a company's performance—both under the perspective of the return on assets as well as market price—there were evidences of inadequacy in the calculation of the Structural Capital and the Efficiency of the Structural Capital. In this sense, they suggested using the extended VAIC™ (Nazari & Herremans, 2007), which is the estimation of Structural Capital based on process and client innovation capitals. Although the extended formulation partially solves the calculation of Structural Capital efficiency by including proxies such as marketing expenses and R&D expenditures, there would still be estimation errors in view of the residual portion for process capital calculation.

Despite the contrast between the rationale for VAIC™ and seminal concepts (Edvinsson & Malone, 1997), it is undeniable that the approach has reached a broad level of dissemination, including the search for answers to very concrete situations linking organizational performance and executive compensation. In this framework, Hooper (2016) identified, for example, a marginal increment of 4.8% in bonuses paid to executives as a result of the increase in the efficiency of Structural Capital.

In addition, VAIC™ has also been used to moderate studies involving governance and performance issues. Malhotra & Thenmozhi (2016) identified interdependence between governance and Intellectual Capital efficiency, proposing that corporate accountability systems are able to attract talent and improve resource allocation. Thus, Financial Capital efficiency and Human Capital efficiency—both predicted as VAIC™ variables—positively affected return on equity.

4 The B3 (BM&FBOVESPA) Corporate Sustainability Index (ISE)

Created in 2005, the Corporate Sustainability Index (ISE) is an initiative of B3 (BM&FBOVESPA) and other entities such as the International Finance Corporation (IFC), which is the World Bank's financial agency, and the Center for Sustainability Studies of the Getúlio Vargas Foundation (FGV-GVCes). This initiative sought to create an investment environment compatible with the demands of sustainable development of contemporary society, stimulating the ethical responsibility of corporations.

The concept of sustainability was first incorporated by the Dow Jones group in the USA with the creation in 1999 of the Dow Jones Sustainability Index (DJSI). In emerging countries, the first business sustainability index was created in 2003 by the

Johannesburg Stock Exchange (JSE) in South Africa (Barakat et al., 2016; ISE, 2016). In Latin America, ISE is the pioneer initiative.

The methodology used to select the companies that make up the ISE portfolio was developed by FGV-GVCes with funding from the International Finance Corporation considering Triple Bottom Line (TBL) concepts, as coined by Elkington (2001), in which companies are accountable for their performance at economic, environmental, social, and corporate governance levels (ISE, 2016).

As part of the selection process, companies are required to answer a questionnaire composed of seven dimensions that assess different aspects of sustainability (FGV, 2016) such as: (i) general (alignment to good sustainability practices, transparency of the corporative information, and anti-corruption practices); (ii) nature of products (individual and diffuse impacts of products and services offered by the firm); (iii) corporate governance (auditing and enforcement processes and practices related to employee conduct and conflict of interests); (iv) environmental; (v) social; (vi) economic-financial; and (vii) climate change.

Each dimension is subdivided into criteria that cover the themes already mentioned. The weights of these criteria are defined by the relevance of the theme in the current context of business management and demands from society. The managerial practices and performance of each publicly held company are highlighted (FGV, 2016).

There is a strong interest from the researchers for investigations addressing the effectiveness of the ISE while generating differentiated value for the shareholders and investors.

In recent national and international surveys, various types of approaches have been used such as comparisons of added value (Mazzioni et al., 2013) and financial returns (Barakat et al., 2016) among the companies participating in the ISE index and the other listed companies (Sousa & Zucco, 2016), analysis of the ISE variation and the profits obtained by the companies that participate in the portfolio and their performance of social actions (Souza et al., 2011) in the B3 (BM&FBOVESPA, and analysis of the correlation between Intellectual Capital and corporate performance (Svanadze & Kowalewska, 2015).

After ten years of consolidation, the ISE portfolio valid for 2016 was institutionally composed of 34 companies representing 16 industries of the economy and reached R$ 960.52 billion in Market Value in December 2015, equivalent to 54.50% of the total value of companies with traded shares. Since its inception in 2005, the ISE had a positive return of 148.3% against 82.9% of the main B3 (BM&FBOVESPA) index (Ibovespa) based on the closing of September 9, 2016 (ISE, 2016).

Companies that are among the 200 most traded on the São Paulo B3 Stock Exchange (BM&FBOVESPA) from a daily liquidity standpoint were invited to be part of the ISE portfolio. Of these, 35 companies were selected for the final composition of the theoretical ISE portfolio. As of 2016, ISE brought together 40 shares from 35 companies, as some companies issue more than one share class, but as of June 2016, Oi Telefônica shares were no longer a part of all market indices due to judicial recovery process. This stage of the portfolio also inaugurates the “long cycle” of the framework as a sustainable company in view of an in-depth review process that takes place every three years, but during 2014 and 2015 B3 consulted companies on the composition criteria. At that time the ISE portfolio received a total of 580 improvement suggestions (ISE, 2016).

The ISE 2016 portfolio presented differentiated characteristics in relation to the general set of companies listed on the B3. In this sense, 93% of them adopt procedures

or practices to evaluate potential impacts (positive or negative) on biodiversity, of which 10% do so systematically in their value chain. In relation to social and environmental practices, 89% of the companies in the portfolio have processes and procedures implemented in relation to applying criteria for managing critical suppliers, which also include in 37% of the cases a commitment to comply with labor legislation in favor of employees (ISE, 2016).

The inclusion of sector or thematic theoretical portfolios is always treated fairly discretely in stock markets as they point additional opportunities to exercise specific investor preferences over the companies in which they participate, such as corporate commitments and purposes. In this sense, the B3-ISE portfolio has been studied, among others, from the point of view of corporate governance (Silva et al., 2019); resource use against intra-organizational social spending (Zanelato et al. (2018); and environmental program spending (Almeida Peixoto et al, 2017). No previous studies reflecting applying the VAIC™ framework to the B3-ISE portfolio were identified.

5 The VAIC™ research on stock market trading

Since the publication of Stewart's (1998) studies on the “Calculated Intellectual Value (CIV)”, there has been a growing body of research focused on the implications of the presence of a significant portion of intangible value embedded in stock prices of companies traded on the stock markets.

At the same time, since the 1990s, various attempts to measure and categorize the origins and flows of Intellectual Capital and Intangible Assets have been made by both researchers and practitioners (Andriessen, 2004).

As anticipated, the axis of analysis in this study falls on the VAIC™ with some anchor points and contrasts with the following investigations.

Kujansivu & Lonnqvist (2007) addressed the simultaneous application of CIV and VAIC™ to study value creation in order to identify competencies in using intangibles to perform better than another organization, or possibly compare business units or industries. Overall, the study confirmed the association between the VAIC™ component Intellectual Capital Efficiency and the productivity and profitability metrics, although it was not possible to identify an association between investments in Intellectual Capital and Intellectual Capital Efficiency since the study covered a multisector sample in which case a distinct dynamic of value creation prevails in each of them.

Laing et al. (2010) applied the VAIC™ model to value creation research in hospitality industry companies in Australia in order to contrast Return on Assets over a four-year series with the presence of intangibles and their efficiency. The findings indicated, after filtering out non-framed observations, the existence of companies creating extraordinary value from Intellectual Capital Efficiency.

Ståhle et al. (2011) studied 125 Finnish listed companies in 2008 in order to identify value creation mechanisms based on Intellectual Capital. The research pointed to the existence of positive and significant interdependence relations for Return on Assets and variables related to VAIC™ calculation — except Invested Financial Capital—but did not identify significant correlation between VAIC™ and the total market value attributed to the company, nor between VAIC™ and MTBV, although there is evidence to point to the existence of interdependence between Market Value and Value Added, Invested Financial Capital, Human Capital, and Structural Capital.

Rahim et al. (2017) investigated the effects of Human Capital Efficiency on the Malaysian technology industry showing average extraordinary returns of 2.64 times per invested currency, ranging from 1.01 to 10.08. A moderate correlation of 0.539 was found, significant to $p < 0.01$, between Human Capital Efficiency and Return on Assets, which allowed them to state that in the Technology Industry, the human factor positively and directly sensitizes profitability (Rahim et al., 2017).

In researching the relevance of Intangible Assets and Intellectual Capital in oil and gas companies, Dzenopoljac & Muhammed (2017) came across the effects of using indicators covering one-year time horizons and proposed that future research should use more extended metrics as investments aimed at developing Intangible Assets would have a longer maturity. The study identified a group of companies that apparently performed better based on intangibles, signaling that even in a long-term tangible asset-intensive industry, Intangible Assets should be better covered by studies facing the Resource Based View (Theriou et al., 2014).

6 Procedures

To deal with the research question of how and how intensely the dimensions that underpin the VAIC™ model interact in the Value Creation of the companies listed in the B3 Corporate Sustainability Index (ISE), this study described and characterized the Value Creation of companies committed to sustainability that are part of the ISE portfolio of 2016 by applying the VAIC™ method. The application of the VAIC™ method is based on two (Human Capital and Structural Capital) of the three theoretical dimensions of Intellectual Capital and its interactions with the Financial Capital that supports the operations of the companies.

Of the five hypotheses, the first two deal with how the VAIC™ would portray Value Creation, the following two are hypotheses of linkage to identify different company profiles, and finally the last hypothesis seeks to portray how intensely the components of the VAIC™ manifest themselves in the organizations of the portfolio studied.

Expanding the original study scope and considering the size of the sample, we used an indiciary approach (Duarte, 1998; Ginzburg, 1989; Richter et al., 2016) in order to explore the existence of some kind of latent relationship between the VAIC™ and MTBV.

The companies portrayed in this research are part of the portfolio valid for the year 2016 of the B3 ISE announced on November 26, 2015 taking into account historical criteria from January 4, 2016 to December 29, 2016 (ISE, 2016). The portfolio includes 34 companies in 16 industries as shown in Appendix 1. In this portfolio, eight companies have been present since its creation in 2005, which shows the dynamism of its evolutionary framework and the anchoring in the ISE approach based on differentiation considering economic efficiency, environmental balance, social justice, and corporate governance.

The data collection was carried out in accordance with international accounting harmonization standards based on International Financial Reporting Standards (IFRS). Consolidated information and Market Value were extracted from the Economática® application (database) and standardized financial statements for the year 2015.

The information extracted from the statements form the basis for calculating the Financial Capital efficiency and IC efficiency coefficients and, therefore, the VAIC™. This proposition ratifies the model as an accounting tool that assists in measuring

efficiency and in evaluating the potentialities of Value Creation (Pulic, 2000), as evidenced in Chart 1.

The research question, i.e. how and how intensely the dimensions that underpin the VAIC™ model interact in the Value Creation of the companies listed in the B3 (BM&FBOVESPA) Corporate Sustainability Index (ISE), has been deployed in the exploratory hypotheses that we present on Chart 2.

Chart 1. Rationale of the variables applied to the VAIC™ Model.

Accounting data	
Value Added (VA)	Represents the current wealth generated. Excerpted from the Value Added Statement (VAS). Account caption: Total Value Added to Distribute.
Invested Financial Capital (FC)	Represents the carrying amount of the firm's net assets. Account caption: Shareholders' Equity.
Human Capital (HC)	Represents the amount of human resources expenditures (wages, benefits, charges, training). Excerpted from VAS. Account caption: Distribution of Value Added / Total Salaries.
Structural Capital (SC)	Represents the amount added to Human Capital to make up the current wealth generated, that is, the difference between Value Added and Human Capital: SC = VA – HC
	[1]
Efficiency Coefficients	
Financial Capital Efficiency (FCE)	Ratio between Value Added and Invested Financial Capital:
	FCE = VA / FC
	[2]
Human Capital Efficiency (HCE)	Ratio between Value Added and Human Capital: HCE = VA / HC
	[3]
Structural Capital Efficiency (SCE)	Ratio between Structural Capital and Value Added, determined in the formulation of Pulic (2000) where Human Capital and Structural Capital are items of proportionally inverse quantities in the formation of Added Value: SCE = SC / VA
	[4]
Intellectual Capital Efficiency (ICE)	Sum of the “efficiency” plots in the Value Creation: (2) + (3):
	ICE = HCE + SCE
	[5]
Value Creation Efficiency	Sum of the “efficiency” plots in Value Creation (2) + (3) + (4):
(VCE or VAIC™)	VCE or VAIC™ = FCE + HCE + SCE
	[6]
Market Metrics	
Market Value (MV)	Number of shares multiplied by the respective price on the stock exchange environment in each category of share issued by the public company
Market to Book Value (MTBV)	Ratio between the price attributed by the market to the stock traded on the stock exchange and that of accounting for the same fraction of the firm's capital: MTBV = MV / FC
	[7]

Source: The authors, variables and equations based on Pulic (2000) VAIC™ framework.

Chart 2 – Reasoning and Hypothesis Unfolding.

Hypothesis	Test	Unfolding	Expected
$H_{0,1}$: There is no currency based interdependence among the *driving dimensions that portray the Value Creation* in the companies of the ISE Portfolio under the Intellectual Capital perspective.	Spearman Correlation	(i) $H_{01,a}$: FC and HC; (ii) $H_{01,b}$: FC and SC; (iii) $H_{01,c}$: FC and MV; (iv) $H_{01,d}$: HC and SC; (v) $H_{01,e}$: HC e MV; and (vi) $H_{01,f}$: SC and MV	Significant positive correlations
$H_{0,2}$: There is no ratio based interdependence among the achievement of *efficiency standard* in a theoretical dimension of Value Creation and the efficiency generated in the other dimensions.	Spearman Correlation	(i) $H_{02,a}$: FCE and HCE; (ii) $H_{02,b}$: FCE and SCE; (iii) $H_{02,c}$: FCE and VAIC™; (iv) $H_{02,d}$: FCE and MTBV; (v) $H_{02,e}$: HCE and SCE; (vi) $H_{02,f}$: HCE and VAIC™; (vii) $H_{02,g}$: HCE and MTBV; (viii) $H_{02,h}$: SCE and VAIC™; (ix) $H_{02,i}$: SCE and MTBV; and (x) H_{02}j: VAIC™ and MTBV	Significant positive correlations
$H_{0,3}$: There are no clusters of companies capable of characterizing the similarities and dissimilarities of the companies of the ISE Portfolio when simultaneously taking into account the dimensions driving Value Creation from the point of view of Intellectual Capital.	ANOVA, MANOVA		At least three significant different categories
$H_{0,4}$: There are no canonical classification functions capable of predicting the categorization of companies of the ISE Portfolio when simultaneously taking into account the dimensions driving Value Creation from the point of view of Intellectual Capital.	χ^2, Predicting %		At least two significant different predicting functions achieving 85% of the cases
$H_{0,5}$: There are no driving dimensions that can be considered more determinant in the Value Creation in the hierarchical clusters of companies when observed in the ISE Portfolio	Wilcoxon Z Test, Kruskal-Wallis H Test	$H_{05,a}$: FCE distributions; (ii) $H_{05,b}$: HCE distributions; (iii) $H_{05,c}$: SCE distributions; (iv) $H_{05,d}$: ICE distributions; (v) $H_{05,e}$: VAIC™ distributions; and (vi) $H_{05,f}$: MTBV distributions	Significant not symmetrical in the three clusters. Significant not symmetrical among the three clusters.

Source: The authors.

The ratio between the Book Value and the consolidated market price (MTBV) has been the kernel of studies for several years, pointing to this metric as evidence of the Value Creation, which can be used to compare the assets of a hypothetical portfolio (Neves et al., 2010; Santanna et al., 2003).

When this ratio is greater than one, it means that the market is appreciating something that is not being fully recorded and recognized by accounting or is being recorded and recognized incompletely. When this ratio is lower than one, it means that

the market is demanding values or events (or part of them) not yet appropriated by the accounting regime and practices (Santanna et al, 2003).

In view of the intended characterization, we sought to frame the study from the functionalist paradigm (Burrel & Morgan, 2005) through quantitative analysis of secondary data to explore and describe the sample studied specifically regarding the Value Creation sources and their relationships.

Our option for a cross sectional study, rather than a panel study or a longitudinal one, was due to our research stage, seeking to collect clues to undertake a more robust study from the point of view of the expansion and comparison of portfolios or the creation/destruction of value over time.

7 Operationalization and findings

We consolidated the data from the Economática® database and from the companies' standardized financial statements for the year 2015 using the SPSS™ application with the computation of [1], [2], [3], [4], [5], [6], and [7] according to the formulations of the variables presented in Chart 1 (Pulic, 2000). Afterwards, we checked the descriptive statistics to verify the patterns of distribution and the conditions of application of hypothesis tests to the cases of the sample studied. When we compare the information in Table 1 with those in Appendix 1, the influence that the organizations of the Banking industry exerts on data and variables adopted to characterize the sample studied is noticeable.

Table 1. Descriptive Statistics for the ISE Portfolio.

	Statistics					
	Minimum	**Maximum**	**Average**	**Standard Deviation**	**Asymmetry**	**Kurtosis**
Data						
Market Value	885,499	150,488,035	25,227,919	31,576,367	2.45	7.14
Value Added	488,515	44,532,000	11,182,312	10,848,744	1.60	2.35
Invested Financial Capital	1,077,767	114,059,000	20,683,177	30,544,132	1.90	2.50
Human Capital	71,335	21,329,593	2,820,022	4,907,858	2.80	7.61
Structural Capital [1]	311,421	27,605,469	8,362,290	7,175,486	1.09	0.90
Variables						
Financial Capital Efficiency [2]	0.16	7.85	1.29	1.63	2.88	8.74
Human Capital Efficiency [3]	1.65	25.12	8.39	6.82	1.11	0.35
Structural Capital Efficiency [4]	0.40	0.96	0.78	0.16	-0.72	-0.52
Intellectual Capital Efficiency [5]	2.05	26.08	9.17	6.95	1.08	0.27
VAIC™ [6]	2.42	28.63	10.46	7.39	0.90	-0.06
MTBV [7]	0.14	10.18	3.59	2.52	0.68	0.14

Source: The authors. N = 34, including the Banking industry - Data in R$ thousand; Variables as ratios.

Although the primary objective is related to the description of the Value Creation in the ISE Portfolio, in order to overcome constraints regarding the specific, strategic, and operational nature of financial institutions and their respective magnitude of the accountable (Cooke, 1989), “Banco do Brasil”, “Bradesco”, “Banco Santander”, “ItauUnibanco”, and “Itaúsa” were displaced from the sample with new calculations presented in Table 2.

Even with the exclusion of the “banking corporations”, a data pattern was identified that does not meet the normal distribution constraints to perform hypothesis tests under conditions of full robustness. Thus, in order to achieve the desired exploratory results in part, we alternated the use of non-parametric tests and the application of tests that were previously recognized as having a narrower scope in terms of full disclosure for the sample studied.

Table 2. Descriptive Statistics for the Adjusted ISE Portfolio.

	Statistics					
	Minimum	**Maximum**	**Average**	**Standard Deviation**	**Asymmetry**	**Kurtosis**
Data						
Market Value	885,499	63,210,697	15,930,510	16,217,500	1.70	2.70
Value Added	488,515	31,167,140	8,340,983	7,202,786	1.36	2.10
Invested Financial Capital	1,077,767	68,567,242	9,908,344	13,873,885	3.29	12.08
Human Capital	71,335	6,004,845	1,277,746	1,409,735	2.19	4.53
Structural Capital [1]	311,421	27,605,469	7,063,236	6,406,876	1.35	2.21
Variables						
Financial Capital Efficiency [2]	0.16	7.85	1.46	1.71	2.68	7.37
Human Capital Efficiency [3]	1.65	25.12	9.06	6.93	1.05	0.16
Structural Capital Efficiency [4]	0.40	0.96	0.81	0.14	- 1.06	0.76
Intellectual Capital Efficiency [5]	2.05	26.08	9.86	7.04	1.02	0.10
VAIC™ [6]	2.42	28.63	11.32	7.42	0.82	- 0.21
MTBV [7]	0.22	12.48	2.80	2.96	1.77	3.21

Source: The authors. N=29, excluding the Banking industry - Data in R$ thousand; Variables as ratios.

7.1 Hypothesis 1

Since the discussion of Value Creation through Intellectual Capital has not yet set standards for accurately measuring the contribution of each of the dimensions per se (here, Human Capital and Structural Capital), it is reasonable to expect latency between these drivers. In addition, on a complexity paradigm, it is also reasonable to expect reinforcement from one variable to another—synergy (Rezende, 2006).

So the hypothesis that discusses the positive interdependence among the driving dimensions that support Value Creation was computed through Spearman's Rho correlation coefficient, which is suitable for distributions in a smaller sample or that do not meet the normality criteria (Field, 2009).

From data collected from the standardized financial statements for the year 2015, the findings were significant for five of the six sub-hypotheses tested (with $p < 0.05$), providing support to refute some of the null unfolding hypothesis in favor of the alternative hypothesis (Table 3).

For $p < 0.05$, there is no evidence to confirm interdependence between Invested Financial Capital and Human Capital, so the null hypothesis $H_{0,1a}$ prevailed.

Table 3. Interdependence Relationship Testing of Value Creation Drivers.

		Invested Financial Capital	Human Capital	Structural Capital
Human Capital	ρ Spearman	0.45		
	Significance	0.14		
Structural Capital	ρ Spearman	0.58	0.62	
	Significance	0.00	0.00	
Market Value	ρ Spearman	0.48	0.50	0.39
	Significance	0.01	0.01	0.04

Source: The authors. N = 29.

According to Figueiredo & Silva (2009), it is possible to affirm the existence of a moderate correlation (between 0.30 and 0.69) among the several dimensions that drive value and a market Value Creation metric. The existence of positive combined and simultaneous effects between the value drivers is therefore confirmed (Bontis, 1998; Sveiby, 1997; Stewart, 1998) and one exogenous information in which an external agent, in this case the stock market, attributes a measure of the performance to the organizations studied.

Through VAIC™ lenses, for the ISE 2016 portfolio, all Intellectual Capital dimensions contributed in the Value Creation process, but the Human Capital is the value driver that has the greatest interdependence with Market Value.

7.2 Hypothesis 2

Considering that the VAIC™ methodology works with the concept of efficiency on the value added from applying the drivers (Financial Capital, Human Capital, and Structural Capital), we discuss Hypothesis 2 in order to identify the complementary effects among the allocation of resources that comprise the Value Added Intellectual Capital coefficient (monetary/inventory assets and intangible assets) in the form of

"value co-creation". To do so, we again applied the Spearman's Rho coefficient with the findings presented in Table 4.

Hypothesis 2 also sought to evaluate the effects of the allocative efficiency for the purposes of assessing the components of the ISE Portfolio based on MTBV for the last B3 (BM&FBOVESPA) session of 2015. The possibility of information asymmetry must be taken into account since the agents do not have full and instant visibility on allocations of expenses and patrimonial effects (Damodaran, 1997; Myers, 1984; Aboody & Lev, 2000).

Table 4. Interdependence Relationship Testing of Value Drivers Efficiency.

		Financial Capital Efficiency	Human Capital Efficiency	Structural Capital Efficiency	VAIC™
Human Capital Efficiency	ρ Spearman	0.45			
	Significance	0.01			
Structural Capital Efficiency	ρ Spearman	0.45	1.00		
	Significance	0.01	0.00		
VAIC™	ρ Spearman	0.56	0.97	0.97	
	Significance	0.00	0.00	0.00	
MTBV	ρ Spearman	-0.38	-0.38	-0.38	-0.43
	Significance	0.04	0.83	0.83	0.86

Source: The authors. N = 29.

As expected, in view of the formulation supporting the VAIC™ methodology, there is a positive interdependence among the effects of the "efficiency" attributed to the Financial Capital, Human Capital, Structural Capital, and VAIC™ sub-hypotheses (H_{02a}, H_{02b}, H_{02c}, H_{02e}, H_{02f}, and H_{02h}) since the efficiencies of Human Capital and Structural Capital are inversely proportional quantities and VAIC™ is the sum of the three Financial Capital Efficiency, Human Capital Efficiency, and Structural Capital Efficiency plots.

We have identified negative correlations as unexpected for the previous associations in MTBV-related hypotheses (H_{02d}, H_{02g}, H_{02i}, and H_{02j}). As far as Financial Capital is concerned, H_{02d}, it is notable that we found an acceptable confidence interval ($p < 0.05$), thus refuting the null hypothesis. Then, moderately, the larger the Financial Capital Efficiency on the VAIC™ framework, the smaller would be the MTBV. This issue will be explored further in the topic Discussions, but we anticipate that in the case of Financial Capital, it would apparently portray a gap in the VAIC™ model to deal with leveraged firms.

7.3 Hypothesis 3

This hypothesis aims to identify the existence of a possible taxonomy, categories, to frame the companies observed in order to place a greater emphasis on understanding and meaning of greater or lesser efficiency of VAIC™ specific variables, whether Soft Skills or Hard Skills (Rezende, 2006), to drive Value Creation through Intellectual Capital.

The arrangement of observations in distinct and complementary hierarchical clusters from the point of view of dissimilarities and similarities is confirmed by applying a univariate and multivariate analysis of variance (Table 5), which allows affirming the

existence ($p < 0.00$) of at least three distinct categories of observations when considering grouping criteria that use the data collected.

Table 5. Distribution of the Dimensions of Value Creation in Hierarchical Clusters.

Dimension	ANOVA		MANOVA		
	Critical (F)	Significance	Test	Critical (F)	Significance
Financial Capital Efficiency	62.12	0.00	Pillai's	31.56	0.00
Human Capital Efficiency	22.60	0.00	Wilks	31.73	0.00
Structural Capital Efficiency	29.99	0.00			

Source: The authors. N = 29.

The three hierarchical clusters presented (C1, C2, and C3), respectively 13, 13, and 3 cases (Appendix 1), taking into account the Ward attachment method that uses the Euclidean squared distance between the observations, in this study computed three variables (R3) to measure related characteristics.

There is statistical support to affirm that all the dimensions of Value Creation have different individual distribution patterns in each hierarchical cluster (ANOVA Test), as well as the clusters being distinguished from the integration of the three dimensions simultaneously (MANOVA Test), being possible to refute $H_{0,3}$ in favor of the existence of three clusters of companies that are listed in the ISE Portfolio that have different characteristics in relation to the respective role on Value Creation.

7.4 Hypothesis 4

Since allocative efficiency can result in better overall performance, and given the growing representativeness of intangibles as assets to be effectively managed in organizations, it is reasonable to assume that academics and practitioners seek frameworks to support arbitrage in securities trading. In this regard, identifying observation grouping patterns into categories would facilitate faster and more accurate decision making.

In view of the satisfactory findings regarding the procedures for identifying hierarchical clusters, it was possible to investigate the existence of discriminant rules for allocative efficiency capable of predicting the respective categories according to the variables and the clusters computed.

The tests confirm, for $p < 0.01$, the existence of at least two canonical discriminant functions (Table 6 and Table 7) with one being representative of Financial Capital Efficiency and the other a composition between Human Capital Efficiency and Structural Capital Efficiency, therefore Intellectual Capital Efficiency.

In the sample observed, the predictive power of Financial Capital Efficiency prevails on the Intellectual Capital Efficiency, being the more robust about the segregation of observed cases (Table 6). This finding is in line with the critical values (F) of Table 5, which are higher for the Financial Capital Efficiency variable when calculating the standard differences among the hierarchical groupings established based on the Ward Method.

Table 6. Canonical Discriminant Functions.

	Eigenvalue	% Explained Variance	Canonical Correlation	Lambda Wilks	χ^2	GL	Sig.
FCE	5.53	66.60	0.92	0.04	80.14	6	0.00
ICE	2.78	33.40	0.86	0.27	33.23	2	0.00

Source: The authors.

Taking into account the structure and weighting coefficients of the canonical discriminant functions (Table 7), a comparison was made between the presence of the case in the "original" hierarchical grouping and the "predicted" hierarchical grouping (Table 8) with the accuracy of 100% of the cases studied (cross validation of 96.6%).

In view of the tests, it is possible to refute $H_{0,4}$, for $p < 0.01$, in favor of the alternative hypothesis, that is to say, there are discriminant functions capable of classifying and predicting cases of companies in the 2016 ISE Portfolio by using variables that indicate Financial Capital Efficiency, Human Capital Efficiency, and Structural Capital Efficiency where the combination of Human Capital Efficiency coefficients and Structural Capital Efficiency represents the Intellectual Capital Efficiency.

Table 7. Matrix of Structure and Weighting.

Macroconstruct – Factor	Correlations		Coefficients	
	F 1	F 2	F 1	F 2
Financial Capital Efficiency (FCE)	0.87	0.47	1.05	0.15
Human Capital Efficiency (HCE)	- 0.18	0.75	- 0.40	0.41
Structural Capital Efficiency (SCE)	- 0.08	0.91	- 0.22	0.69

Source: The authors.

Table 8. Comparison between clustering and forecasting.

		Cluster	Participation forecasted in cluster			Total
			1	2	3	
Original	Counting	C1	13	0	0	13
		C2	0	13	0	13
		C3	0	0	3	3
	Percentage	C1	100.00	0,00	0.00	100.00
		C2	0.00	100.00	0.00	100.00
		C3	0.00	0,00	100.00	100.00
Cross Validation	Counting	C1	13	0	0	13
		C2	0	13	0	13
		C3	0	1	2	3
	Percentage	C1	100.00	0.00	0.00	100.00
		C2	0.00	100.00	0.00	100.00
		C3	0.00	33.30	66.70	100.00

Source: The authors.

From the centroids of the clusters it is possible to point out that the three cases in C3 appear to have greater allocative efficiency of Financial Capital, while the thirteen cases in C2 have lower allocative efficiency of Intellectual Capital. The remaining observations in C1 would have lower allocative effectiveness with respect to Financial Capital and a small advantage, as a group, in the effectiveness of Intellectual Capital. But such propositions will be better explored below.

7.5 Hypothesis 5

The findings of $H_{0,5}$ (differences of the patterns among the efficiency in the resources application considering the three hierarchical clusters) were complemented by tests to identify symmetry or the existence of different efficiency standards among and within the hierarchical groupings (Rezende, 2006).

Thus, Kruskal-Wallis H tests were applied on standardized variables (Z score) for comparing hierarchical clusters in pairs (C1 & C2, C1 & C3, and C2 & C3) as shown in Table 9, and confirm the expected results when calculating the discriminant functions in the development of $H_{0,4}$: there are significant differences in relation to the allocative efficiency of the dimensions driving the Value Creation according to the VAIC™ methodology.

Taking into account a 95% confidence interval, it is supported to state that: (i) with respect to $H_{0,5a}$ (Financial Capital Efficiency), it is possible to affirm that the greater magnitude in the C3 companies prevails both over C1 and C2; (ii) with respect to $H_{0,5b}$ (Human Capital Efficiency), it is possible to affirm that the companies of C1 prevail over those of C2 and those of C3 prevail over those of C2; (iii) with respect to $H_{0,5c}$ (Structural Capital Efficiency), it is possible to affirm that the companies of C1 prevail over those of C2 and those of C3 also prevail over those of C2; (iv) with respect to $H_{0,5d}$ (Intellectual Capital Efficiency), it is also possible to affirm that the companies of C1 prevail both over those of C3 and C2 and also that those of C3 prevail over C2.

On $H_{0,5e}$ and $H_{0,5f}$, it is not possible to affirm the existence of significant differences of symmetry, but C2 companies register the lowest Value Added Intellectual Coefficients (VAIC™) and in an apparent paradox, the highest MTBV.

In order to establish an initial route for this last question, we mapped the distribution between MTBV and Intellectual Capital Efficiency (Figure 2) where there is a clear separation of patterns.

Table 9 also presents comparisons based on the Wilcoxon Z-Test for the standardized scores among the drivers of Value Creation within each hierarchical clusters: (i) in the C1 it is supported to assert, with $p < 0.05$, that the allocative Invested Financial Capital Efficiency is overcome by Human Capital Efficiency, by Structural Capital Efficiency, and by Intellectual Capital Efficiency as a whole; (ii) in C2, Invested Financial Capital Efficiency prevails over the other drivers; and (iii) in C3, considering just the three cases observed, there is no statistical support for statements considering $p < 0.05$.

So, (i) C1 is composed of almost all companies in the Brazilian electric sector with a strong premium charged by the capital market; (ii) C2 is more diversified and, although with less efficient allocation of Intellectual Capital, it facilitates the market to assign a better appreciation; (iii) two of the three observations of C3, which holds the best Financial Capital Efficiency and an intermediary Intellectual Capital Efficiency, present the highest MTBV. In view of these six findings, it is reasonable to partially refute $H_{0,5.}$ so therefore there is some evidence to affirm that C2 firms are less efficient on the VAIC™ framework's value driving dimensions.

Table 9. Standardized efficiency coefficients of Value Creation in the hierarchical clusters.

HC	Statistics [a]	Financial Capital Efficiency	Human Capital Efficiency	Structural Capital Efficiency	Intellectual Capital Efficiency	VAIC™	MTBV
C1	X	- 0.24	0.83	0.80	0.84	0.74	- 0.23
	S	0.37	0.89	0.22	0.88	0.88	0.94
	N	13	13	13	13	13	13
	HCE [b]	**0.00**					
	SCE [b]	**0.00**	0.97				
	ICE [b]	**0.00**	0.35	0.97			
	VAIC™ [b]	**0.00**	**0.00**	0.60	**0.00**		
	MTBV [b]	0.86	**0.01**	**0.00**	**0.01**	**0.02**	
C2	X	- 0.37	- 0.82	- 0.90	- 0.82	- 0.87	0.41
	S	0.28	0.15	0.79	0.16	0.20	1.01
	N	13	13	13	13	13	13
	HCE [b]	**0.00**					
	SCE [b]	**0.01**	0.86				
	ICE [b]	**0.00**	0.20	0.86			
	VAIC™ [b]	**0.00**	**0.04**	0.65	**0.03**		
	MTBV [b]	**0.10**	**0.00**	**0.01**	**0.00**	**0.00**	
C3	X	2.62	- 0.06	0.44	- 0.05	0.56	- 0.79
	S	1.06	0.51	0.41	0.51	0.44	0.40
	N	3	3	3	3	3	3
	HCE [b]	0.11					
	SCE [b]	0.11	0.11				
	ICE [b]	0.11	0.11	0.11			
	VAIC™ [b]	0.11	0.11	0.11	0.11		
	MTBV [b]	0.11	0.29	0.29	0.29	0.29	
Sample	X	0.00	0.00	0.00	0.00	0.00	0.00
	S	1.00	1.00	1.00	1.00	1.00	1.00
	N	29	29	29	29	29	29
	HCE [b]	0.86					
	SCE [b]	0.58	0.51				
	ICE [b]	0.85	0.58	0.52			
	VAIC™ [b]	0.89	**0.03**	0.57	**0.03**		
	MTBV [b]	0.89	0.92	0.80	0.92	0.80	
1 – 2 [c]		0.29	**0.00**	**0.00**	**0.00**	0.49	0.24
1 – 3 [c]		**0.01**	***0.09***	***0.09***	**0.00**	0.95	0.31
2 – 3 [c]		**0.01**	**0.01**	**0.01**	**0.01**	0.94	0.25

[a] Calculated from the standardization of variables for Z score. [b] Comparisons between cluster indexes based on Wilcoxon Z-Test. [c]Comparisons between the indexes in each cluster based on the Kruskal-Wallis H Test. Value in bold = $p < 0.05$; Values in bold and italic. = $p < 0.10$. Source: The authors.

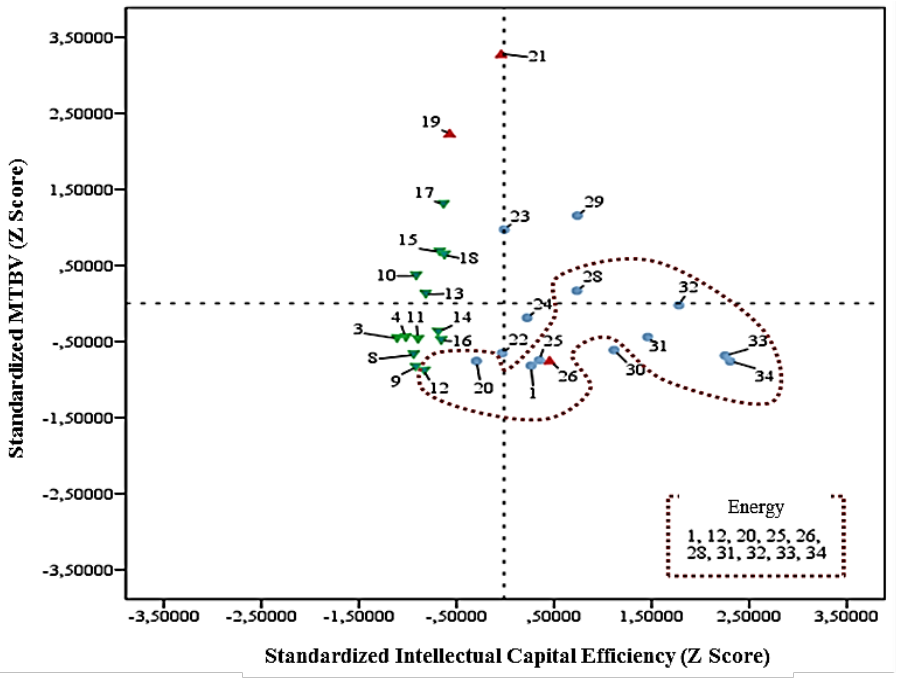

Figure 2. ICE versus MTBV scattered plotting. Source: The authors.

8 Discussion and final remarks

This study aimed to apply the reasoning of VAIC™ in the quest to describe and characterize Value Creation in companies listed in 2016's B3 ISE.

The ISE portfolio was chosen in view of the growing appeal for adopting sustainable management practices, and the year 2016 corresponds to the eleventh edition of this B3 portfolio in BM&FBOVESPA.

We have analyzed the consolidated data of the standardized financial statements as of December 31, 2015 for 29 of the 34 companies that make up the ISE.

Although the portfolio analyzed does not include as a rule of formation filters that highlight adopting issues related to Intellectual Capital Management, the application of the VAIC™ has brought contributions that appear to broaden possibilities for discussing Value Creation.

Thus, in attempting to solve the research question of how and how intensely the dimensions that underpin the VAIC™ model interact in the Value Creation of the companies listed in the B3 (BM&FBOVESPA) Corporate Sustainability Index (ISE), we formulated five hypotheses that consisted in analyzing the interdependence of the Value Creation drivers and the efficiency coefficients expressed in the VAIC™ model and in characterizing the hierarchical clusters making it possible to analyze the similarities and dissimilarities of the companies of the theoretical portfolio.

The operationalization of hypothesis $H_{0,1}$ "there is no currency based interdependence among the data of the Value Creation drivers in the companies of the ISE Portfolio under the Intellectual Capital perspective", and with the unfolding of $H_{0,2}$ "there is no interdependence among efficiency ratio in a Value Creation driver and the efficiency in one another", it was possible to confirm previous theoretical propositions regarding the interdependence of Value Creation drivers from the integrated mix of

resources considering tangible and intangible assets, which is mainstream for the strategic approach of the Intellectual Capital Management view.

As the study variables come from aggregated information in theoretical constructs and not by direct observation, it is reasonable to consider the existence of some latency among them. Regarding both Stewart's (1998) and Pulic's (2000) frameworks, the additive and interdependent character in the computation of macroconstructs is evident.

So, in view of the tests, moderate positive correlations were evidenced between the value drivers and the market capitalization as well as among the drivers themselves. However, no significant confirmation was found considering value drivers and the MTBV ratio interdependence when analyzing the efficiency coefficients.

Our study identified that using Value Added (VA) data obtained directly from the standardized financial statements as a source for simultaneous determination of both HCE and SCE with complementarity between them may lead to a loss of explanatory capacity for Value Creation. For example, the same pattern of ratio interdependence between the Financial Capital Efficiency and the Human Capital Efficiency, and between the Financial Capital Efficiency and the Structural Capital Efficiency; or between the Human Capital Efficiency and the Market to Book Value and the Structural Capital Efficiency and the Market to Book Value (Table 4).

So from an ontological point of view, VAIC^{TM} ought to be used with parsimony because, although the set of procedures is simple, there are potential bias on Human Capital and Structural Capital, mainly because of the additive nature and formulation of these two data/variables and respective proportions in each of the observations on the sample.

Another confirmation refers to the presentation of distinct categories encompassing the 29 companies of the sample: clusters of companies that presented different characteristics in relation to the Value Creation. In this way, it was possible to organize them into hierarchical clusters of 13, 13, and 3 cases respectively, as well as based on discriminant functions, to predict them on the clusters.

So the development of hypotheses $H_{0,3}$ "there are no clusters of companies capable of characterizing the similarities and dissimilarities of the companies of the ISE Portfolio when simultaneously taking into account the Intellectual Capital Value Creation drivers" and $H_{0,4}$ "there are no classification functions capable of predicting the categorization of companies of the ISE Portfolio, while taking into account the Intellectual Capital Value Creation drivers", advance for understanding the characteristics of the companies listed in the ISE Portfolio, although they meet previous and common management criteria for operating on a sustainable and responsible way, they can present differentiated Value Creation drivers.

Based on the VAIC™, identifying three distinct hierarchical clusters (C1, C2, and C3) and classification rules for the 2016 ISE Portfolio are evidences of the need to advance in the discussion of Value Creation based on intangibles and their respective reflections on the market capitalization. The findings and the organization's mix of each one of these clusters (Figure 2) reinforce the propositions of Theriou et al. (2014) on different industry dynamics of Value Creation based on Intellectual Capital Efficiency.

By consolidating the data and the operational variables, it was possible to deepen the identification of the characteristics of each cluster and to understand the relationship between the VAIC^{TM} components and aspects observed in the firms of the 2016 ISE portfolio.

Appendix 2 points out that C1 groups the companies with higher levels of price attribution by the market, firms that present high added value, and are those that hold

the largest volume of Invested Financial Capital. They also present a large volume of Structural Capital applied in operations. Most are energy/electricity companies, so they operate with large investments in facilities (CAPEX). From the point of view of data and variables, as well as the standardized scores computed, C1 is the one that brings together the cases with the best efficiency indicators for Human Capital, Structural Capital, and Intellectual Capital. In view of this, they present the best result for the VAIC™ indicator.

For C1 we noted the emphasis on Human Capital Efficiency for Value Creation. Here, the VAIC™ is practically equivalent to C3, but C3 does not have the same C1 average MTBV. So, although Value Creation has been observed on C1, it may not be perceived by the market. Most of C1 companies operate in a highly regulated environment that has suffered with imposed implications of reducing energy tariffs in 2012, culminating high losses to the Eletrobrás system with the need to inject billions of Brazilian Reais to support the tariff reduction. This poorly planned intervention appears not to have been well accepted by the market. But there are also organizations on C1 from highly technology dependence industries, which according to Rahim et al. (2017), could explain the emphasis on the Human Capital Efficiency.

The companies that make up C2 are those that have relatively lower Market Value and those that, as a group of the sample, add less value. In them there is a lower application of Structural Capital in the operations and they are the ones that present lower absolute and standardized results for the efficiency of all the components of the VAIC™ (respectively in Appendix 2 and Table 9). C2 group is the one that presents the cases with the best MTBV ratios, including from the point of view of standardized scores.

C2 is heterogeneous, covering various industries, depicting smaller companies than C1. It is the cluster that presented the frequency distribution of the most compressed VAIC™ (Figure 3) in order not to stand out from either the FCE or ICE (HCE + SCE) point of view. However, the C2 companies are more appreciated than those of C1 by the MTBV criteria, possibly because the market is effectively charging risk premiums from the energy industry.

In C3, there are firms (only three cases) that signal greater value addition, so greater allocation of resources in Human Capital and Structural Capital, but these organizational choices do not result in greater efficiency of Human Capital and Structural Capital, and the higher VAIC™ coefficient found for this group derives from the greater allocative efficiency of Invested Financial Capital. C3 presents the cases with lower values for absolute MTBV and standardized MTBV.

An unexpected *a priori* finding brings clues about the appreciation of companies in the Brazilian market, or at least in the portfolio studied. Since the VAIC™ methodology works with the equity value and does not take leverage into account, some notes need to be preserved for future studies: (i) the Financial Capital Efficiency would not be enough to reverse the inefficiency of the vectors that integrate capital intellectual, mainly Human Capital, as typified in C3; and (ii) the Intellectual Capital Efficiency, particularly Human Capital, mitigates inefficiency of Financial Capital, as typified in C1.

In a broad sense, for the complete sample studied, it is possible to observe that there are “clues” about interpolation of the cases based on VAIC™ and MTBV, but without characterizing significant predictive power, as in Ståhle et al. (2011). Thus, if it were possible to establish a kind of “threshold”, an increase of one point in the VAIC™ would bring forty-one hundredths to the MTBV (Figure 3).

Figure 3 presents a more compact pattern for the 13 observations grouped in C2 than in the 13 observations present in C1. At the same time, it is possible to identify

distinct ranges for the Value Added Intellectual Capital coefficients: the VAIC™ levels of the C2 firms would be more restricted than those of the C1 firms; there is no significant difference in the MTBV distribution pattern in the three hierarchical clusters ($H_{0,5}$ unfolding, Table 9).

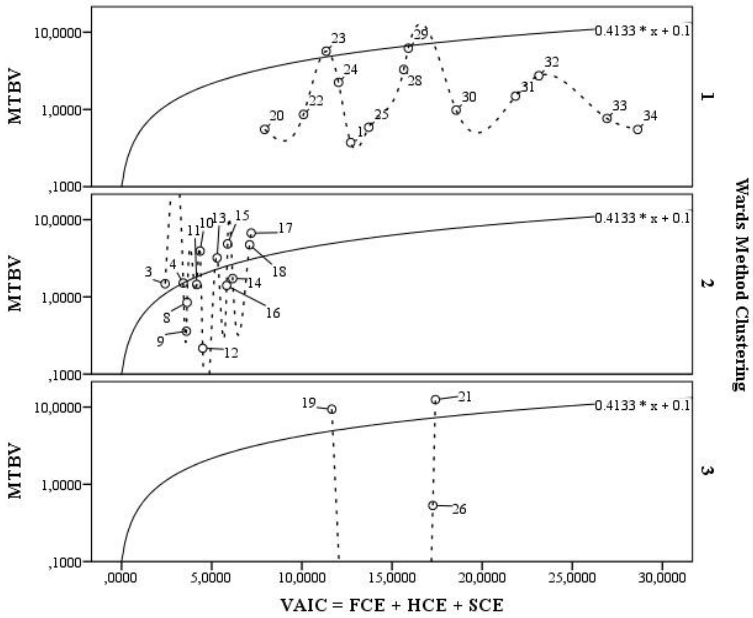

Figure 3. Interpolation between VAIC™ and MTBV. Source: The authors.

It is reasonable to notice that the C2 companies, a diversified group for the economic sectors, are concentrated in low VAIC™ scores. The C1 companies, most from the electrical sector or with large fixed costs, extend the range of VAIC™ scores, that is, they would present potential greater addition of Intellectual Capital. But it seems that C2 is more volatile, while C1 has a long dispersion with the majority of cases being below the interpolation curve. This finding is intriguing because firms from the electric energy industry, grouped in C1, appear to be competing with different strategies and resource allocation mixes, even on a regulated basis, opening up opportunities for intangible pricing arbitrage for C2 companies.

From the combination of the dispersions pointed out in Figures 2 and 3, it is reasonable to consider that C1 companies are more impacted, according to the VAIC™ view, with the current practices of disclosure and measurement of Intellectual Capital in their statements than those of C2.

The results of our study reinforce the propositions of Ståhle et al. (2011) regarding the complementarity between Human Capital and Structural Capital, reducing the robustness for the estimation effect of Market Value. From the point of view of the optimization of Invested Financial Capital, the present findings are in line with that discussed by Zia ul haq et al. (2014). In view of the implementation efforts, we agree with Svanadze & Kowalewska (2015) on simplicity in capturing and operationalizing data that take into account more than the economic perspective of shareholders (Iazzolino et al., 2014).

In view of the size of the clusters, it was not possible to operate partial correlation procedures in relation to the VAIC™ and MTBV, and there is no evidence to reinforce

the propositions of Malhotra & Thenmozhi (2016) regarding the interdependence between Human Capital, Structural Capital, and performance. By adopting MTBV as a proxy for economic performance, we identified a paradoxical moderate negative correlation, significant at $p < 0.05$, between Invested Financial Capital and MTBV and we did not find a significant result for the correlation between Human Capital and MTBV.

Near the end of this research's final writing, the mainstream media reported that one of the companies categorized in C3 of our study publicly assumed through a leniency agreement related to “Operation Car Wash” to have paid kickbacks to executives of the state-owned company Petrobras in view of agreements without legal or regulatory protection to establish the price of naphtha, an essential raw material for petrochemicals, trough collusion.

Since “Cluster 3” shows a behavior that stands out enough from the others, to the point that we have proposed the debugging of these companies for a new round of research procedures, we believe that the method adopted here makes it possible to hear eventual noises and anomalies in the formation of theoretical portfolios, which accentuates the need and possibilities of new unfolding and deepening of the technique for the purpose of monitoring market events.

That company is previously listed to be a part of the 2017 ISE Portfolio, as announced by B3. One of the attributes to stay in the portfolio is to be compliant with anti-corruption precautions and practices: the firm and respective external auditing asseveration point that the issue is periodically discussed, monitored, and assessed.

After the leniency agreement, the share price increased and according to market makers there is room for more appreciation.

So, for the scholars, here there is more room for questioning information asymmetry and the alignment between the ISE criteria safeguards and external auditing practices, bolding the value of the “new economics” of the Intellectual Capital and Intangible Assets (Hand & Lev, 2003).

Possible challenges arise from the research findings both theoretically and for practitioners: (i) how to stimulate scenarios and traders to improve market capitalization in view of intangible assets already owned; (ii) how to enhance intangibles so that they are perceived and increase Market Value; (iii) to what extent it would be possible to conduct price arbitrage above and below a possible VAIC^{TM} threshold.

It is important to highlight that, based on hypothesis $H_{0,5}$, “there are no Value Creation drivers that can be considered more determinant in the hierarchical clusters when observed in the ISE Portfolio”, cluster C3, composed by only three observations (Table 9), presents a pattern of allocative efficiency of the Invested Financial Capital superior to the other cases observed, which in a neighboring situation could lead to the characterization of these three companies as multivariate outliers. Since the 2016 ISE Portfolio was already reduced with the disregard of financial institutions, Petrobras, and Oi S.A, we decided to maintain the three observations that gave rise to C3.

It is also worth mentioning the limitation of the VAIC™ model in that it cannot fully encompass the conception of Value Creation given that its methodology does not consider the variable Relational Capital in its relations among Human Capital and Structural Capital.

The theoretical implications of the findings relate to the possibility of strengthening the proposals of the mainstream related to Intellectual Capital Management, which is the co-creation of value through the interactions among flows and inventories of intangibles.

For practitioners, the implications relate to new possibilities for understanding Value Creation either by the VAIC™ model or other artifacts already proposed to identify specific patterns of categorization of companies from the dimensions of Human Capital, Relational Capital, Structural Capital, and capital market indicators, such as MTBV.

The limitation faced with the small number of observations points to the development of future studies on the research question conjectured (i) from the construction of panel analysis with the several years and observations already portrayed by the ISE Portfolio; (ii) based on modeling that allows comparisons among ISE companies and the others traded on the B3 (BM&FBOVESPA); (iii) from comparative case studies to analyze in greater depth effects such as that determined in the definition of the C3 cluster under unexpected strong influence of the Invested Financial Capital Efficiency.

Our synthesis proposition, despite criticism and unlike the purposes that led to the development of the VAIC™ method, is that it becomes a subsidiary instrument to support discussions on the mental model that forges the business and management solutions being used in organizations.

Measurement initiatives, bringing together frameworks driven by hard skills with those of soft skills, are the key to developing ambidextrous organizations, those with greater ease to expand the Value Creation from combining tangible and intangible assets.

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Appendix 1. Listing, data, and variables of the ISE 2016 portfolio (financial data in R$ thousand).

	Industry	Organization	Code	Invested Financial Capital	Market Value	Added Value	Human Capital	Structural Capital	FCE	HCE	SCE	ICE	VAIC™	MTBV	Cluster
1	Electric Energy	Copel	CPLE6	14,584,478	5,446,068	14,456,447	1,337,474	13,118,973	0.991	10.809	0.907	11.716	12.707	0.373	1
2	Banking	Banco Brasil (*)	BBAS3	86,229,994	41,162,229	38,413,622	21,329,593	17,084,029	0.445	1.801	0.445	2.246	2.691	0.477	NA
3	Aeronautical	Embraer	EMBR3	15,008,670	22,248,551	5,527,827	3,342,390	2,185,437	0.368	1.654	0.395	2.049	2.418	1.482	2
4	Health	Fleury	FLRY3	1,655,439	2,500,694	1,226,816	571,733	655,083	0.741	2.146	0.534	2.680	3.421	1.511	2
5	Banking	Santander BR	SANB11	79,835,284	57,209,381	14,883,671	6,829,965	8,053,706	0.186	2.179	0.541	2.720	2.907	0.717	NA
6	Banking	Bradesco (*)	BBDC3	90,914,762	100,043,545	29,340,796	12,244,544	17,096,252	0.323	2.396	0.583	2.979	3.302	1.100	NA
7	Banking	ItauUnibanco (*)	ITUB3	114,059,000	150,488,035	44,532,000	17,609,000	26,923,000	0.390	2.529	0.605	3.134	3.524	1.319	NA
8	Building Supplies	Duratex	DTEX3	4,616,476	3,912,166	1,802,228	686,654	1,115,574	0.390	2.625	0.619	3.244	3.634	0.847	2
9	Building	Even	EVEN3	2,466,162	885,499	488,515	177,094	311,421	0.198	2.759	0.637	3.396	3.594	0.359	2
10	Industrial Goods	Weg	WEGE3	6,156,060	24,112,073	5,707,748	2,050,734	3,657,014	0.927	2.783	0.641	3.424	4.351	3.917	2
11	Commerce	B2W Digital	BTOW3	2,706,133	3,918,959	1,658,001	571,158	1,086,843	0.613	2.903	0.656	3.558	4.171	1.448	2
12	Electric Energy	Eletrobras	ELET3	41,739,222	9,034,105	19,951,059	6,004,845	13,946,214	0.478	3.322	0.699	4.022	4.500	0.216	2
13	Meat & Food	BRF Brasil Foods	BRFS3	13,835,853	44,307,621	16,286,114	4,768,435	11,517,679	1.177	3.415	0.707	4.123	5.300	3.202	2
14	Highways	Ecorodovias	ECOR3	1,638,454	2,832,412	1,872,675	440,249	1,432,426	1.143	4.254	0.765	5.019	6.162	1.729	2
15	Paper & Cellulose	Klabin S/A	KLBN11	5,352,340	25,968,329	4,039,356	927,354	3,112,002	0.755	4.356	0.770	5.126	5.881	4.852	2
16	Assurance	Sul America	SULA11	4,430,871	6,219,408	2,607,368	584,317	2,023,051	0.588	4.462	0.776	5.238	5.827	1.404	2
17	Commerce	Lojas Americanas	LAME3	2,943,605	19,732,679	5,283,238	1,145,637	4,137,601	1.795	4.612	0.783	5.395	7.190	6.704	2
18	Commerce	Lojas Renner	LREN3	2,310,896	10,938,716	3,766,752	804,253	2,962,499	1.630	4.684	0.786	5.470	7.100	4.734	2

	Industry	Organization	Code	Invested Financial Capital	Market Value	Added Value	Human Capital	Structural Capital	FCE	HCE	SCE	ICE	VAIC™	MTBV	Cluster
19	Personnel Products	Natura (*)	NATU3	1,077,767	10,107,371	6,272,471	1,244,978	5,027,493	5.820	5.038	0.802	5.840	11.660	9.378	3
20	Electric Energy	Cesp (**)	CESP6	7,310,892	4,036,226	1,163,920	168,146	995,774	0.159	6.922	0.856	7.778	7.937	0.552	1
21	Petrochemicals	Braskem (*)	BRKM5	1,337,711	16,690,447	10,496,192	1,209,732	9,286,460	7.846	8.676	0.885	9.561	17.408	12.477	3
22	Telecom	Telefônica Brasil	VIVT4	68,567,242	59,065,822	31,167,140	3,561,671	27,605,469	0.455	8.751	0.886	9.636	10.091	0.861	1
23	Highways	CCR AS	CCR03	3,904,312	22,158,119	6,117,780	688,031	5,429,749	1.567	8.892	0.888	9.779	11.346	5.675	1
24	Paper & Cellulose	Fibria	FIBR3	12,815,320	28,707,990	7,661,841	727,641	6,934,200	0.598	10.530	0.905	11.435	12.033	2.240	1
25	Electric Energy	Cemig (*)	CMIG4	12,999,113	7,643,700	18,187,991	1,595,391	16,592,600	1.399	11.400	0.912	12.313	13.712	0.588	1
26	Electric Energy	Eletropaulo (*) (**)	ELPL4	2,839,145	1,512,258	11,978,826	987,742	10,991,084	4.219	12.127	0.918	13.045	17.264	0.533	3
27	Banking	Itausa (***)	ITSA4	44,847,000	46,861,260	11,140,000	813,000	10,327,000	0.248	13.702	0.927	14.629	14.878	1.045	NA
28	Electric Energy	Engie Brasil	EGIE3	6,642,136	21,860,336	4,121,326	292,274	3,829,052	0.620	14.101	0.929	15.030	15.650	3.291	1
29	Financial Services	Cielo	CIEL3	10,163,967	63,210,697	8,549,113	604,804	7,944,309	0.841	14.135	0.929	15.065	15.906	6.219	1
30	Telecom	Tim Part S/A	TIMP3	16,933,044	16,602,823	14,265,135	850,362	13,414,773	0.842	16.775	0.940	17.716	18.558	0.980	1
31	Electric Energy	CPFL Energia (*)	CPFE3	10,130,138	15,073,956	17,366,310	905,103	16,461,207	1.714	19.187	0.948	20.135	21.849	1.488	1
32	Electric Energy	AES Tiete	TIET11	2,018,466	5,512,920	1,528,934	71,335	1,457,599	0.757	21.433	0.953	22.386	23.144	2.731	1
33	Electric Energy	Energias BR	ENBR3	7,488,447	5,725,911	9,005,639	363,659	8,641,980	1.203	24.764	0.960	25.724	26.926	0.765	1
34	Electric Energy	Light S/A	LIGT3	3,669,622	2,018,947	9,331,741	371,449	8,960,292	2.543	25.123	0.960	26.083	28.626	0.550	1

*Companies listed since the composition of the ISE portfolio **Only individual organizational statements available – BRGAAP. ***Data from Holding – BRGAAP; FCE: Invested Financial Capital Efficiency; HCE: Human Capital Efficiency; SCE: Structural Capital Efficiency; VAIC™: Value Added Intellectual Coefficient; MTBV: Market to Book Value. Source: data from Economática®; variables from the authors.

Appendix 2. Hierarchical Cluster Statistics.

		Statistics				
	C	**Average**	**Median**	**Standard Deviation**	**Minimum**	**Maximum**
Data (R$ K)						
Market Value (MV)	1	19,774,117	15,073,956	20,142,563	2,018,947	63,210,697
	2	13,585,478	9,034,105	12,876,385	885,499	44,307,621
	3	9,436,692	10,107,371	7,611,289	1,512,258	16,690,447
Value Added (VA)	1	10,994,101	9,005,639	8,180,418	1,163,920	31,167,140
	2	5,401,361	3,766,752	5,941,449	488,515	19,951,059
	3	9,582,496	10,496,192	2,960,870	6,272,471	11,978,826
Invested Financial Capital (FC)	1	13,632,860	10,130,138	17,103,488	2,018,466	68,567,242
	2	8,066,168	4,430,871	11,005,143	1,638,454	41,739,222
	3	1,751,541	1,337,711	950,818	1,077,767	2,839,145
Human Capital (HC)	1	887,488	688,031	916,530	71,335	3,561,671
	2	1,698,066	804,253	1,852,907	177,094	6,004,845
	3	1,147,484	1,209,732	139,459	987,742	1,244,978
Structural Capital (SC)	1	10,106,614	8,641,980	7,336,948	995,774	27,605,469
	2	3,703,296	2,185,437	4,200,135	311,421	13,946,214
	3	8,435,012	9,286,460	3,071,616	5,027,493	10,991,084
Variables (Ratios)						
Invested Financial Capital Efficiency (FCE)	1	1.05	0.84	0.63	0.16	2.54
	2	0.83	0.74	0.49	0.20	1.79
	3	5.96	5.82	1.82	4.22	7.85
Human Capital Efficiency (HCE)	1	14.83	14.10	6.15	6.92	25.12
	2	3.38	3.32	1.01	1.65	4.68
	3	8.61	8.68	3.55	5.04	12.13
Structural Capital Efficiency (SCE)	1	0.92	0.93	0.03	0.86	0.96
	2	0.67	0.70	0.11	0.40	0.79
	3	0.87	0.88	0.06	0.80	0.92

		Statistics				
Intellectual Capital Efficiency (ICE)	1	15.75	15.03	6.18	7.78	26.08
	2	4.06	4.02	1.12	2.05	5.47
	3	9.48	9.56	3.60	5.84	13.05
VAIC™	1	16.81	15.65	6.56	7.94	28.63
	2	4.89	4.50	1.48	2.42	7.19
	3	15.44	17.26	3.28	11.66	17.41
MTBV	1	2.75	2.14	1.97	0.37	6.22
	2	4.38	3.69	2.00	0.22	6.70
	3	1.32	1.80	6.20	0.53	12.48

Source: The authors. Sample n = 29; C1, n = 13; C2, n = 13; C3, n = 3.